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CHEMICAL & ENGINEERING
NEWS

PACIFIC BASIN

New age dawns for chemicals
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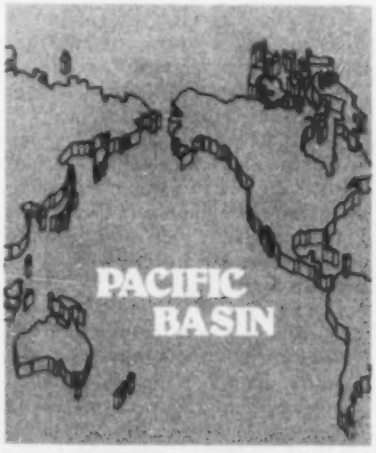

News Focus

Pacific Basin, with its high level of opportunities for chemical development, provides focus for the new era of chemistry that is emerging, as global chemical industry responds to societal and marketing challenges. **Page 7**

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LETTERS

CHEMICAL SAFETY

Potential hydroperoxide hazard

SIR: This letter calls attention to a potential hazard associated with the analysis of hydroperoxides.

In an analytical determination of hydroperoxide, one of the reagents is a saturated solution of sodium iodide in 2-propanol. An accident occurred when a technician, who intended to refill a bottle containing this reagent, chose a bottle of cumene hydroperoxide by mistake and poured about 700 mL of cumene hydroperoxide into 25 mL of sodium iodide in 2-propanol solution. The mixture decomposed violently, sending glass fragments throughout the lab area. Eye protection and lab coats prevented all but very minor injuries.

In subsequent testing, when 1 g of sodium iodide in 2-propanol was added to 30 g of 86% cumene hydroperoxide in a calorimeter at 26 °C, there was a rapid evolution of gas and heat (350 calories). Addition of 1 g of solid sodium iodide to 30 g of cumene hydroperoxide gave evolution of gas and 83 calories of heat. Addition of 2-propanol to the hydroperoxide gave little heat and no gas.

We believe these results show that small quantities of sodium iodide can catalyze a hazardous decomposition of cumene hydroperoxide at room temperature. The iodometric analytical procedure evidently avoids the gas-forming (catalytic) decomposition of the hydroperoxide by providing an excess of iodide (10 mL of sodium iodide in 2-propanol, about 13 milliequivalents of iodide); significant heat effects are avoided by restricting the sample size (not more than 2.5 milliequivalents of hydroperoxide or 190 mg of cumene hydroperoxide).

A. A. Duswalt, *Research Scientist*
H. E. Hood, *Research Associate*
Hercules Research Center
Wilmington, Del.

Effective use of databases

SIR: John Crum's analysis of the status of ACS finances (C&EN, Dec. 4, 1989, page 41) provides plenty of food for thought for all ACS members. I would like to point out one of the implications of the funding of ACS programs by other, self-sufficient ACS activities. I wrote in a letter to the editor (C&EN, Feb. 6, 1989, page 3) that users of chemical information were being harmed by the ACS policy of refusing to license certain *Chemical Abstracts* files, to commercial on-line vendors such as Orbit, Dialog, and Questel. The official ACS response at the time, as stated by Newman Bortnick, was that I was concerned only with convenience, and that there was little real damage to information users caused by the licensing policy.

Objections to that licensing policy continue to be strong in the information community, as reported to the ACS Council by Joseph A. Dixon, Bortnick's successor as chairman of the CAS committee (C&EN, Nov. 20, 1989, page 32). Dixon has also conceded that our objections to the licensing policy are based on a real concern about our ability to provide excellent service, and not on mere convenience. But he defended the need for the licensing policy in terms of CAS's need to maximize its income, because of the need of the income to subsidize important ACS programs.

At the open meeting of the CAS committee in Miami Beach, Dixon was asked whether it is right to use CAS as a cash cow to fund other ACS programs, at the expense of damaging the ability of information users to make the most efficient and effective use of CAS databases. I believe that the question is important enough to be brought before the entire membership of ACS. This ACS member believes that CAS databases should be made available to information users in formats and with database clusters that allow them to be used to maximum effect. If that has a negative effect on CAS income (still a debatable point), then let us find more appropriate means of funding those programs that are deemed desirable by the membership.

Stuart M. Kaback
Cranford, N.J.

Raise chemists' salaries

SIR: Dennis J. Sardella (C&EN, Nov. 20, 1989, page 3) was intrigued with the possibility of interpreting the decade-long decay of science enrollment in terms of socioeconomic factors. I would like to explore the problem, but minimize the socio slant. I prefer to view the problem and solution as economy and human nature. The solution could, but probably does not, require increased federal investment in education (C&EN, Nov. 20, 1989, page 5). Want more chemists? Raise chemists' salaries.

It is hypothesized that raising teachers' salaries will attract better teachers. Presumably, "better" teachers are recognized from a larger pool of candi-

Emerging Biotechnology Products Focus of Patent Disputes

Competing for markets and betting their survival on a few major products, biotech drug companies have lots at stake in patent rights battles

Ann M. Thayer,
C&EN Northeast News Bureau

Now that more and more genetically engineered drugs are close to becoming marketed products, patent rights will play a major part in determining which of the numerous biotechnology companies control major markets.

Currently, 45 companies have 80 products based on genetic engineering that are under development, according to the Pharmaceutical Manufacturers Association. Food & Drug Administration approval has been granted to only 10 biotechnology drugs, but about the same number of applications is pending.

The number of new major biotechnology products reaching the market is expected to rise throughout the 1990s. U.S. sales of human therapeutic and diagnostic biotechnology products will reach almost $1.3 billion in 1990, according to Consulting Resources Corp. of Lexington, Mass., growing to about $3.7 billion by 1995 and $9 billion by 2000. Despite the potential for large rewards, the costs for a biotechnology company are high—as much as $100 million per product and possibly even the fate of the company. The level of competition is also very high with at least two companies, if not many more, in each of the major product areas.

Cancer treatments account for the largest area of development, with 45 products, and include the interferons, interleukins, and monoclonal antibodies. Vaccines for hepatitis and AIDS (acquired immune deficiency syndrome) treatments are other major areas of R&D. Among the first drugs to be approved were interferon, human growth hormone, and insulin. The potential blockbusters, erythropoietin (EPO), which stimulates the production of red blood cells, and tissue plasminogen activator (TPA), a blood clot dissolving agent, have been approved in the past three years. Granulocyte colony stimulating factors (GCSF), which control the production and activity of white blood cells, and monoclonal antibodies, used to treat various cancers and septic shock, are on the horizon as some of the next big biotechnology drugs.

Although all the major areas of biotechnology drug development are seeing patent litigation, the trend in the industry is more toward cross-licensing than litigation, says David Webber, a biotechnology analyst with the firm of Alex. Brown & Sons in New York City. An important early example was the cross-licensing of the α-interferon patents between Schering-Plough and Hoffmann-La Roche, licensees of Biogen of Cambridge, Mass., and Genentech of South San Francisco. Not the panacea for cancer once expected, Webber believes the α-interferon market, already about $150 million worldwide, will continue to expand as clinical trials lead to other drug indications. γ-Interferon has recently been cross-licensed by Biogen and Genentech.

Similarly, the interleukins—used in cancer and immunotherapy treatments but not yet approved in the U.S.—have been cross-licensed. A patent dispute over interleukin-2 (IL-2) between Cetus of Emeryville, Calif., and Amgen of Thousand Oaks, Calif., was settled through a licensing agreement. A more important agreement, adds Webber, is that between Cetus and Hoffmann-La Roche, considered to be bigger players in the market.

Cetus led in drug patents based on biotechnology in 1988

	Biotechnology patents		
	Pharmaceuticals	Pharmaceuticals based on genetic engineering	Major drug development areas
Amgen	3	3[a]	Anemia, cancer, infection, hepatitis
Biogen	2	2	Cancer, AIDS, inflammation
Burroughs-Wellcome	3	0	Heart attack, cancer
Cetus	12[a]	6[a]	Cancer, AIDS, infection, diagnostics
Du Pont	3	1	Diagnostics
Genentech	11[a]	9[a]	Diabetes, cancer, AIDS, heart attack, human growth
Genetics Institute	5	4[a]	Anemia, hemophilia, cancer, infection, heart attack
Hoffmann-La Roche	5[a]	0	Human growth, cancer
Eli Lilly	11[a]	4[a]	Cancer, diabetes, diagnostics, heart attack, human growth
Ortho Pharmaceutical	6	4[a]	Anemia, transplants

a Among top 10 recipients of biotechnology patents in the U.S. in 1988. Source: Pharmaceutical Manufacturers Association

Hoffmann-La Roche was willing to negotiate, even sweetening the deal by taking a 3.5% stake in the biotechnology company and providing it with some needed capital. In the fiscal year ending June 30, 1989, Cetus reported losses of nearly $50 million, caused, in part, by spending for the launch of its IL-2 product. Since IL-2 will be Cetus' first major product, and FDA approval is expected this year, the firm could not afford the risk of being blocked from the market, he explains.

"It's possible for a company to be excluded from the marketplace, no matter how much good work it's done in the lab and clinic, if it doesn't have the right set of patent rights," says Webber. "It's often cheaper and more beneficial to try to settle a patent dispute out of court." Patent litigation is a two-edged sword, he adds, since one's own patent rights are put at risk when challenging another's.

The risk is considered fairly high since many unanswered questions surround biotechnology patents. For example, the U.S. Patent & Trademark Office, which has a backlog of thousands of patent applications, is just beginning to come to grips with granting patents in such a new and rapidly advancing technology. And the courts have yet to deal with issues on the scope and validity of patent claims. This is in contrast to the established pharmaceutical industry where both business practices and patent law are more mature. "With a lack of precedents, in terms of both case law and how the [biotechnology] industry will sort out such disputes," says Webber, "a cloud of uncertainty hangs over most of the products of these companies."

Companies would like to have guidelines as to what is patentable and how the courts will view biotechnology patents since the uncertainties affect their stock prices, business activities, and the outlook of investors. "It's probably a little early to try to extract any trends," says William S. Feiler, a patent attorney with the firm of Morgan & Finnegan in New York City. "I suspect that we are going to see the pace [of litigation] pick up when people get a better feel for how the courts are going to react on certain issues or how they will interpret claims." At least a dozen significant cases are pending, but very few decisions have come out.

On a case-by-case basis, there have been some important precedents, says Feiler, but only one U.S. case involving genetic engineering has been fully litigated. Hybritech, now a subsidiary of Eli Lilly, sued Monoclonal Antibodies, a Mountain View, Calif.-based biotechnology company, alleging that Monoclonal Antibodies' immunoassay kit infringed Hybritech's patent. In 1985, the U.S. District Court in San Francisco ruled that Hybritech's patent was invalid since the invention claimed would have been obvious to a person of ordinary skill in the field at the time the invention was made.

The patent was upheld by the U.S. Court of Appeals for the Federal Circuit, the highest court, other than the U.S. Supreme Court, to hear patent cases. Explains Peter Ludwig, an attorney with the firm of Darby & Darby in New York City, obviousness is measured against four criteria. These are the scope and content of any prior art; the differences between the prior art and the claimed invention; the level of skill in the art of the invention; and any evidence of secon-

Prior publication dooms patent application

In an area with few precedents, the U.S. Court of Appeals for the Federal Circuit has established an important one on the conditions for obviousness in biotechnology inventions. An invention is patentable if it differs from any description in the prior art, such as other patents or publications, available more than a year before an application is filed. The court's August 1988 decision, *in re O'Farrell*, made clear that inventors will not be protected against the apparent obviousness of their invention, even if the prior art is their own scientific publication.

In 1978, the University of California filed for a patent on a method of producing a predetermined protein in genetically engineered bacteria, based on work by Patrick H. O'Farrell, Barry A. Polisky, and David H. Gelfand. The patent application was rejected in 1981 as being obvious, based on a 1976 paper by Polisky, Robert J. Bishop, and Gelfand describing a method for the expression of frog ribosomal RNA in genetically engineered bacteria. The university also became involved in a dispute over a competing patent application filed in 1977 by the biotechnology company, Genentech. Genentech received a broad patent on recombinant proteins in 1987. After appealing the rejection of the patent, the case went to the court of appeals.

Although the O'Farrell patent claims were very similar to the method described in the 1976 paper, the inventors argued that there were important differences. Based on existing precedents, an invention still may be patentable even if it is "obvious to try." If there is not a reasonable expectation of success, or undue experimentation is required, or the technology is so new that the prior art gives only general guidelines, it may be considered not obvious. Since proteins had not been produced successfully by recombinant techniques, it was argued that success with a gene encoding for a protein, rather than RNA, was not certain. However, the court ruled that the prior art explicitly suggested the method and substitutions made between it and the claimed invention.

"It is hard to escape from thinking that the court adopted a strict construction of the [published] article because it had been authored by two of the three inventors of the patent application under review," comments Peter Ludwig, a patent attorney with the firm of Darby & Darby in New York City. In referring to it as the case of "publish and perish," he stresses the need to balance the "opposing forces of publication and patenting," in protecting university-based inventions. It was a "judicial anomaly," he says, that the appeals court also chose to comment on the patent of an unrelated party in its decision. Opinions differ as to whether the court's comments, suggesting that the Genentech patent followed on the work done by O'Farrell et al., might be used in challenges of the broad Genentech patent.

dary considerations such as commercial success, unexpected results, or long-term need. Although the Hybritech case was uniquely decided on the fourth criterion, questions as to how the three remaining tests for obviousness will be applied to biotechnology inventions continue to be significant issues in patent cases, says Ludwig.

In an initial stage of a case between Genetics Institute, Cambridge, Mass., and Amgen, one of the first decisions relating to the issues of validity, infringement, and enforceability of two patents was made. The two companies are battling over rights to EPO. In its first year, sales of EPO are expected to be more than $100 million and, if approved for treatment of anemia in cancer and AIDS patients in addition to those with kidney failure, the market could reach $300 million. Amgen received FDA approval for its EPO in June 1989; Genetics Institute has not received approval, but has been expected to for some time.

Certain claims of both companies' patents were upheld and found to be infringed by the other party, says Feiler. However, Genetics Institute's licensee, Chugai Pharmaceutical of Tokyo, was not found to infringe the Amgen patent. Amgen's patent covers the gene sequence, vectors, and transformed host cells—intermediates in the product of recombinant EPO. Genetics Institute's patent covers purified EPO.

"It's an important precedent that the pure protein claim will cover a recombinant product," says Feiler. The decision by the court was not completely unexpected. In a case between Genentech and Scripps Clinic & Research Foundation involving Factor VIII, the blood clotting agent used to treat hemophilia, the Scripps patent on the purified protein was upheld initially. The case is on appeal. That a patent on a purified natural protein covers all forms of the protein, whether produced by recombinant or other means, is expected to have significant ramifications for the biotechnology industry.

An example is the situation now faced by Amgen and Genetics Institute. "In a strategic sense, Genetics Institute came up the winner in this round," says Webber. Genetics Institute is trying to block Amgen from marketing EPO in the U.S., but Amgen cannot block Genetics Institute and its licensee from importing EPO made in Japan. However, the case is not yet completely over.

"The question for Amgen at this point, having really lost the first important round, is whether it should reach an agreement with the other party," he points out. Process patent applications filed by the two companies for production of EPO are being held up in interference proceedings at the patent office. If Amgen were to get a process patent, it is possible that it could block Chugai from importing materials made in a foreign country with a process covered by a U.S. patent, resulting in a standoff between the companies.

There are incentives for both parties to settle. "Amgen has had a high operating budget this year in order to prepare for the launch of its product," Webber says, "and can hardly afford the interruption in EPO revenue flow." Amgen reported a net loss of slightly more than $8 million for the fiscal year ending March 31, 1989, on revenues of more than $67 million. Genetics Institute, which reported a loss of nearly $29 million for the year ending Nov. 31, 1989, would like to begin manufacturing in the U.S. rather then only receiving royalties on U.S. sales of its EPO by its licensee.

With 1989 revenues of more than $400 million, and two major products on the market, Genentech can afford to defend aggressively its patent positions. "The cost of litigation is high, especially for a small company," says Stephen Raines, Genentech vice president for intellectual property, "but compared to the cost of development, it's a very inexpensive route if you are successful." Litigation may cost a few million dollars for the rights to products worth hundreds of millions. The company's two major products, human growth hormone and TPA, had 1989 sales of about $123 million and $196 million, respectively.

Soon after receiving its patents on human growth hormone, the company became involved in infringement suits with Eli Lilly and Hormone Research. In August 1988, the Federal District Court in San Francisco found that Genentech did not infringe the patent held by Hormone Research and its licensee, Hoffmann-La Roche. The case is currently pending on appeal, as is one between Genentech and Lilly. As an alternative to litigation, Hoffmann-La Roche and Lilly signed a cross-licensing agreement on human growth hormone in 1987. For similar reasons, Genentech and Genetics Institute have decided to cross-license Factor VIII with their respective licensees, Miles Laboratories and Baxter Healthcare.

Genentech has had some setbacks. It lost its patent rights to TPA in England in an appeal of a dispute with Wellcome (C&EN, July 13, 1987, page 5). And some initial judgments in U.S. cases have not gone entirely smoothly for the company. "It's worth the gamble," believes Raines, with questions surrounding biotechnology patents so unsettled. "The only thing you generate for all your work and investment is patents," he stresses, "and if you don't assert them, it's almost the same as if you didn't have them." To become a major pharmaceutical company, he explains, a small company must have market exclusivity. Genentech has been, or currently is, involved in suits with several companies over TPA.

However, TPA has not turned out to be the blockbuster drug once expected. Before FDA approval for Genentech's TPA in late 1987, the market was estimated at nearly $250 million for its first year and close to $1 billion now, says Webber. The market and competition from other products, which many believed would drop out with the appearance of TPA, was seriously misjudged. Second-generation TPA and new drugs are starting to emerge.

Expanding markets for the approved drugs and several new multimillion-dollar markets are expected in the 1990s. But the biotechnology industry will still be left with questions surrounding its major patents. "It's going to take time for the whole system to adjust," says Raines. "We're not happy living in this era; we'd like to see the law get settled." □

Switzerland's Science, Technology Policy Undergoes Critical Analysis

OECD review of Alps nation's research efforts dovetails with recent Swiss examination of the aims and institutions of country's R&D policy

Dermot A. O'Sullivan, C&EN London

The general perception of Switzerland is that of a country in which science and technology combine to play a key role in national life. This is exemplified in many areas of endeavor, from the world-renowned precision of Swiss watches to the sophisticated pharmaceuticals and chemicals developed in the country.

For science and technology to flourish, spending on research and development must be maintained at a fairly high level. Much, too, depends on the conditions in which the R&D effort is conducted and maintained, and the underlying policies at the national level that foster scientific advances. These and related issues are the subject of a detailed review of Switzerland's national science and technology effort undertaken by the Paris-based Organization for Economic Cooperation & Development.

Although the review serves to confirm the importance attributed to the research and development effort by the Swiss, it does pinpoint areas of the system that could be improved. One suggestion stems from the need for more scientists and engineers. Another derives from the spirit of independence that the 26 cantons, or states, seek to maintain in the face of planning by the federal authorities in Bern. Also, there is a recognition of weakness in fostering growth in some of the newer areas of scientific endeavor, such as information technology and genetic engineering.

The OECD analysis appears at a time when the Swiss themselves are going through an across-the-board examination of their science and technology effort. This examination is directed toward reshaping the aims and institutions of the country's research policy. As Flavio Cotti, head of Switzerland's Federal Department of Home Affairs, points out, ways to strengthen cooperation between universities and industry is a primary concern of the country's Council of Ministers. No less important is the continuing assessment of research, and of measures that need to be taken to encourage it.

Switzerland's gross domestic spending on R&D in 1986 (the most recent year cited in the OECD study) came to just short of $2.87 billion, nearly 2.9% of the country's gross domestic product (GDP). Industry accounted for 79% of the total, public funding 21%. "This makes Switzerland the OECD member country with the highest business enterprise participation in the funding and implementation of R&D, and with the lowest public sector involvement," the OECD report notes.

The number of people engaged full time in R&D throughout the country in 1986 amounted to 45,000, some 12% of whom are women. Of the total, 35,000 were associated with business enterprises, 7100 were involved in higher education, and 2900 worked in one of the branches of the federal government.

Set against GDP, Switzerland is among the most highly R&D intensive of the 24 OECD member countries. In fact, the 2.9% of GDP spent in 1986 likely is an underestimate because it doesn't take into account the R&D expenditure from a number of sources. Not included, for example, is the direct funding of R&D activities by cantons and communes over and above their contributions to the general universities fund, or the R&D activities of the country's federal institutes of technology in Lausanne and Zurich. Neither do the figures reflect contributions from private, nonprofit bodies, R&D undertaken by the service sector, nor funding that comes from outside the country.

Chemicals high in R&D spending as percent of sales

$ Millions (1986)	Sales	R&D spending as % of sales
Chemicals	$6553	27%
Electrical engineering	4830	16
Machinery & metallurgy	7756	7
Research labs	216	28
Others[a]	8742	2
TOTAL	$28,097	12%

a Other sectors are construction, food products, paper and textiles and clothing, and watchmaking.
Source: Swiss Union for Commerce & Industry

The data cited in the review, drawn largely from information supplied by the Swiss Union for Commerce & Industry, point to some interesting facts. By far the highest amount of R&D spending was made by the Swiss chemical industry. The $1.75 billion or so represented more than 50% of the $3.26 billion invested by the 10 industry groups analyzed. Of the chemical industry's total, 51% was spent in Switzerland.

The chemical industry's spending on R&D in relation to its total sales also was one of the highest of the industry groups. The $1.75 billion represents nearly 27% of the $6.55 billion in chemical sales.

The relative intensity of R&D activity by the chemical industry is

further highlighted by the fact that the 109 companies that make up the group are only a quarter of the number that make up the machinery and metallurgy group, the largest in terms of the number of companies and the number of employees. Moreover, chemical firms account for less than 10% of the 1157 enterprises in all of the 10 industry groups studied. Nevertheless, the 9300 staff members engaged full-time on chemical R&D exceed 14% of the chemical industry work force, in contrast to 6% in the case of the machinery and metallurgy industry, which employs twice the number of workers.

The electrical engineering industry is next in importance in terms of R&D funding, although well below chemicals. The $784 million spent, 16% of the electrical industry's sales, represented 24% of the 10 industry groups' total.

The OECD study draws attention not only to the substantial amount (38% of the 1986 total) of R&D undertaken outside Switzerland, "but also to the fact that expenditure on R&D abroad is growing more rapidly than domestic expenditure. This probably reflects a deliberate international attitude as much as a relative scarcity of scientific and technical personnel in Switzerland."

A coordinated national science policy for Switzerland got under way in earnest in the 1960s. Since then, various bodies have emerged to foster its implementation. The Swiss Council of Science, an advisory body to the federal government, was created in 1965. It sets out the basis of national science and research policy, and proposes measures for its implementation. One permanent working party deals with university policy, another with research policy.

Switzerland's Research Act, which came into force in 1984, provides a legal framework for various research stimulation measures. These include subsidies for research centers in such specialized fields as electronics and microtechnology, encouragement of ancillary scientific services like technical information and documentation, and Swiss participation in a number of international scientific organizations and collaboration in various international research programs. Within the act, coordination of research is the primary responsibility of the research bodies.

The most prominent of these is the Swiss National Science Foundation. Established in 1952, it serves as the country's main research promotion agency. The bulk of SNSF's funds goes toward supporting research at Switzerland's seven universities and its institutes of higher learning in Lausanne, St. Gall, and Zurich. Some of the money is used to help young scientists study outside the country. The foundation's current 1988 through 1991 program, funded at about $400 million, puts special emphasis on environmental studies and on emerging engineering technologies. The program is the first formulation of a coherent approach to research support by the national government.

SNSF also participates in selecting topics for Switzerland's national research programs in special applied research areas of social importance, and is responsible for implementing the programs. Work now under way within the national research program plan includes research in microelectronics and optoelectronics, applications of artificial intelligence and robotics, and studies on biomedical techniques and new materials.

The Swiss Council of Science has set up a permanent body to conduct what's referred to as an advance warning in research policy. By monitoring developments in science, the economy, and society at large, the federal government is provided with specialized assessments of the opportunities and risks associated with various developments. These assessments are available to all of the country's science bodies and to the general public.

The OECD study cites three areas of influence on Swiss science and technology policy. One is the distribution of function between state and private industry. Funding for education and basic research comes largely from government but industry picks up most of the tab for applied R&D.

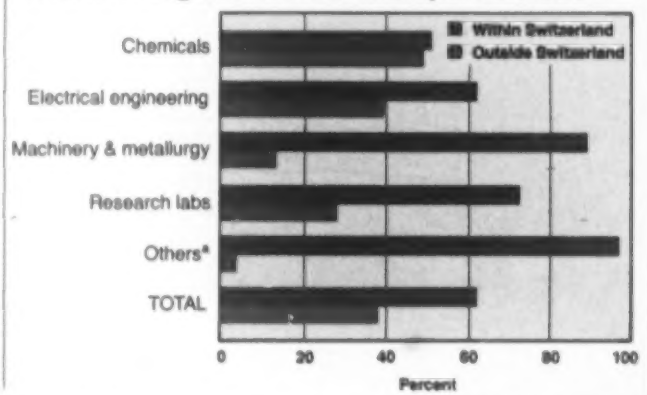
Now there is a tendency for these lines of demarcation to blur somewhat. Closer ties are being forged between educational and research establishments and industry, and more public funding is finding its way to industry-related R&D. "The main reason for this is the acceleration of technological development,

Chemical sector spends most on R&D . . .

$ Millions, 1986	R&D spending	% of total	Within Switzerland	% of total	Outside Switzerland	% of total
Chemicals	$1753	54%	$897	45%	$856	69%
Electrical engineering	784	24	481	24	303	24
Machinery & metallurgy	522	16	455	23	67	5
Research labs	61	2	44	2	17	1
Others[a]	138	4	132	6	6	1
TOTAL	**$3258**	**100%**	**$2009**	**100%**	**$1248**	**100%**

a Other sectors are construction, food products, paper and plastics, technical services, textiles and clothing, and watchmaking.
Source: Swiss Union for Commerce & Industry

. . . and a large amount of it is spent abroad



which is causing problems for small and medium-size firms in particular, and the very large subsidies given by governments to research and technology in countries in competition with Switzerland," OECD notes.

Another area centers on the autonomy of the Swiss universities and state influence on the direction of research undertaken by them. The federal government fixes the long-term objectives of research policy and can impose these objectives directly, a factor that must be kept in mind by grant recipients. "Coordination of research, on the other hand, is to a large extent based on the principle of voluntary cooperation among the bodies concerned, a principle to which exceptions are rare," the study adds.

The third area cited in the OECD review stems from the idea of federalism in Switzerland. The cantons are primarily responsible for education policy. The federal government can curtail their powers only in specific circumstances. This has consequences for the unity of the education and research system and for research conducted at the universities, although the federal government's subsidization of higher education and research provides it with some influence.

"These three areas have strongly marked the development of federal science policy in Switzerland, and have occasioned some setbacks," the OECD review points out. "There has, however, been continuing progress in recent years, and the encouragement of research by the federal government has attained a respectable level. On the other hand, there does not yet exist in Switzerland a government technology policy for reasons inherent in the distribution of functions between the state and the private sector.

"Nevertheless, there appears to be the beginning of a technology policy resulting from the encouragement given to applied research, and from a growing awareness of the implications for technology policy of other government activities. The technology policy debate is likely to become increasingly important in Switzerland over the next few years." □

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